Buckling Analysis of Fuselage Frame Using CAD/CAM Software

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Abstract—The objective of this project is to study the strength of an aircraft fuselage when subjected to buckling due external load acting on it for different materials and composites. Literature survey designates some structural problems due to the external loads leads to this work. This involves design of an aircraft fuselage which has been modeled using CATIA and buckling analysis using ANSYS. This briefly explains the basics of the aircraft structures, composites, finite element method and its application using ANSYS. The analysis is carried out in ANSYS. Composite materials are used for the production of fuselage and that have very high range of load carrying capacity. From this work it is clear that there is a tremendous progress in the buckling load carrying capacity. To felicitate as a research,incorporated fuselage of an aircraft that would utilize the benefits of designing software, and structural analysis using ANSYS Software to designate the buckling analysis under external loads.

***Keywords**: Buckling analysis, fuselage frame and ansys.*

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I. Introduction

A. Composite Materials

The word composite in the term composite materials signifies that two or more materials are combined on a macroscopic scale to form a useful third material. Different materials can be combined on a macroscopic scale such as in alloying of metals, but the resulting materials is, for all practical purpose, macroscopically homogeneous, i.e., the composite cannot be distinguished by the naked eye and essentially act together.

B. Classification of Composite Materials

- Fibrous composite materials that consist of fibers in a matrix.
- Laminated composite materials that consist of layers of various materials.
- Particulars composite materials that are composed of particles in a matrix.
- Combination of some or all of the first three types.

C. Types of Buckling Analyses

Two techniques are available in the ANSYS Multiphysics, ANSYS Mechanical, ANSYS Structural, and ANSYS Professional programs for predicting the buckling load and buckling mode shape of a structure: nonlinear buckling analysis, and eigenvalue (or linear) buckling analysis. Because the two methods can yield dramatically different results, it is necessary to first understand the differences between them.

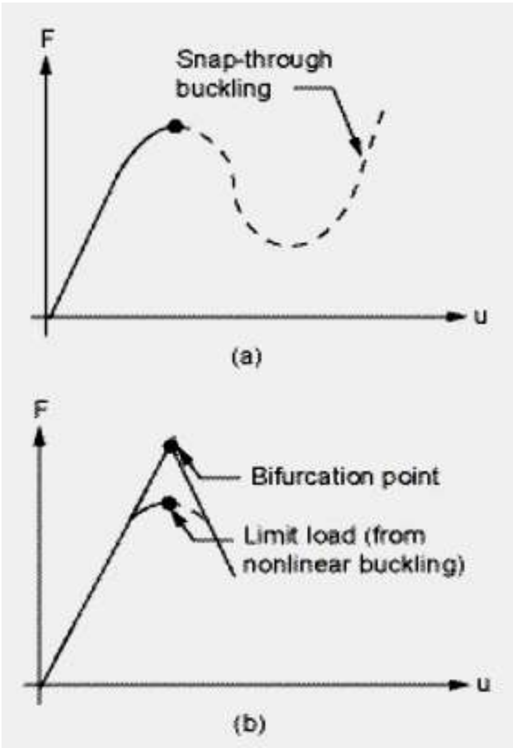

Fig. 1.Buckling Curves a) Nonlinear load-deflection curve, (b) Linear (Eigenvalue) buckling curve.

D. Performing a Nonlinear Buckling Analysis

A nonlinear buckling analysis is a static analysis with large deflection active (NLGEOM,ON), extended to a point where the structure reaches its limit load or maximum load. Other nonlinearities such as plasticity may be included in the analysis. The procedure for a static analysis is described in "Structural Static Analysis", and nonlinearities are described in "Nonlinear Structural Analysis".

E. Performing a Post-Buckling Analysis

A post-buckling analysis is a continuation of a nonlinear buckling analysis. After a load reaches its buckling value, the load value may remain unchanged or it may decrease, while the deformation continues to increase. For some problems, after a certain amount of deformation, the structure may start to take more loading to keep deformation increasing, and a second buckling can occur. The cycle may even repeat several times.

F. Procedure for Eigenvalue Buckling Analysis

Again, remember that eigenvalue buckling analysis generally yields unconservative results, and should usually not be used for design of actual structures. If you decide that eigenvalue buckling analysis is appropriate for your application, follow this procedure:
1. Build the model.
2. Obtain the static solution.
3. Obtain the eigenvalue buckling solution.
4. Expand the solution.
5. Review the results.

II. DESCRIPTION

The research concentrates on technologies adopted for the buckling analysis of fuselage frame.

A. Modal Analysis

A technique used to determine a structure's vibration characteristics:

- Natural frequencies
- Mode shapes
- Mode participation factors

Several mode extraction methods are available in ANSYS:

- Block Lanczos (default)
- Subspace
- Power Dynamics
- Reduced
- Unsymmetric
- Damped (full)
- QR Damped

B. Procedure for Modal Analysis

Four main steps in a modal analysis:

- Build the model
- Choose analysis type and options
- Apply boundary conditions and solve
- Review results
- Remember density
- Linear elements and materials only. Nonlinearities are ignored.

III. DESIGNING AND MESHING DETAILS OF FUSELAGE FRAME

Design of the fuselage frame is done using CATIA V5R21(fig.2) software and analysis is carried out using the Ansys.

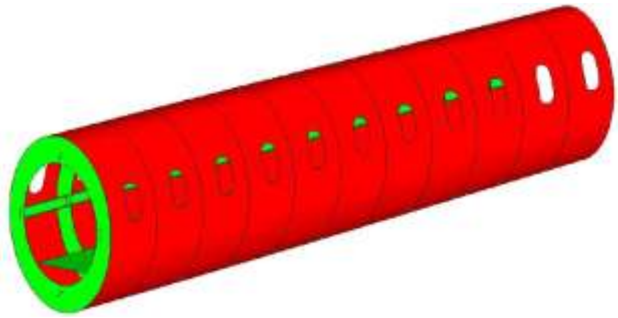

Fig. 2.CAD Model of fuselage frame .

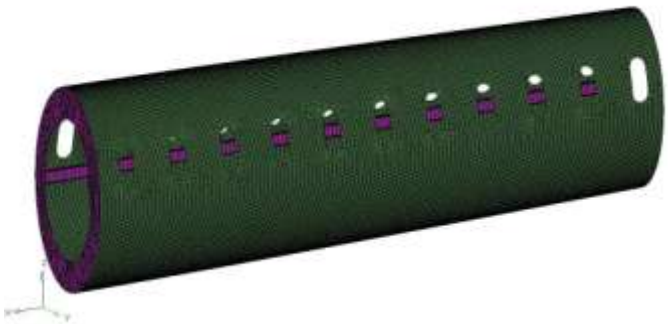

Fig. 3.Mesh (1) of fuselage frame.

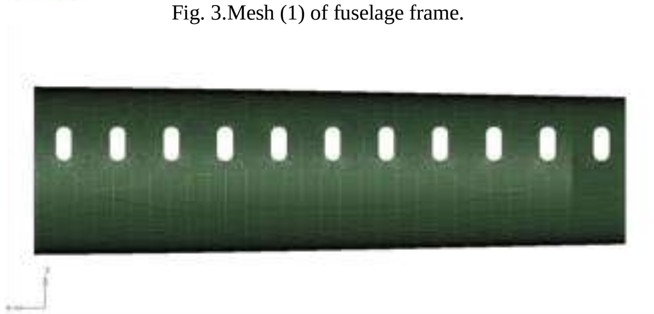

Fig. 4.Mesh (2) of fuselage frame.

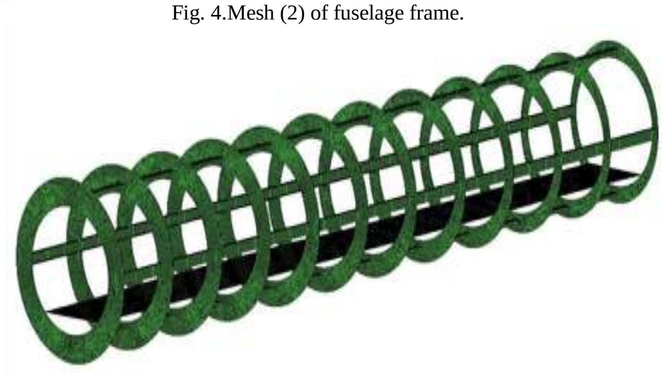

Fig. 5.Mesh (3) of fuselage frame.

A. Material Properties

Inner components – Aluminium
Outer skin – Graphite Epoxy

TABLE I. MATERIAL PROPERTIES

Sl. No.	Material	Young's Modulus(N/m^2)	Density (Kg/m^3)	Poisson's Ratio
1	Aluminium	7.20E+10	2810.00	0.33
2	Graphite Epoxy	1.81E+11	1600.00	0.28

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IV. ANALYSIS RESULTS OF FUSELAGE FRAME IN ANSYS

The fuselage frame analysis is done using ANSYS software and different parameters like stress, total area, load, deflection and strain, buckling effect can be noted to understand the load characteristics over the designed fuselage frame.

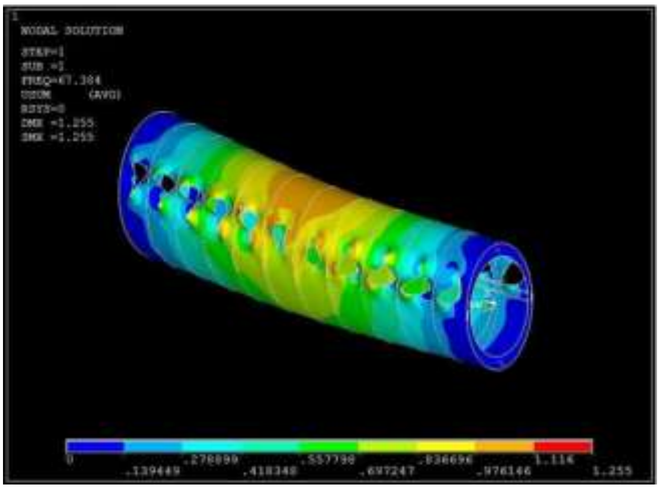

Fig. 6.Mode shape-1 Analysis result

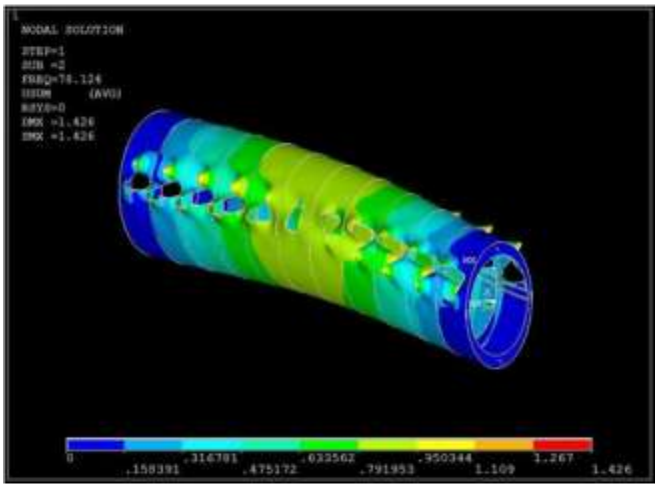

Fig. 7.Mode shape-2 Analysis result.

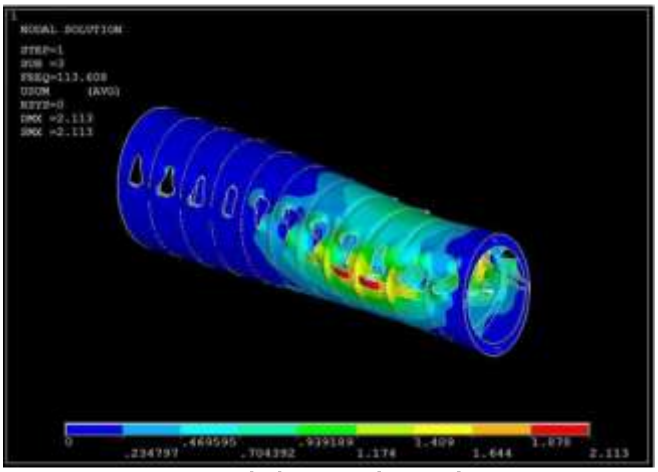

Fig. 8.Mode shape-3 Analysis result.

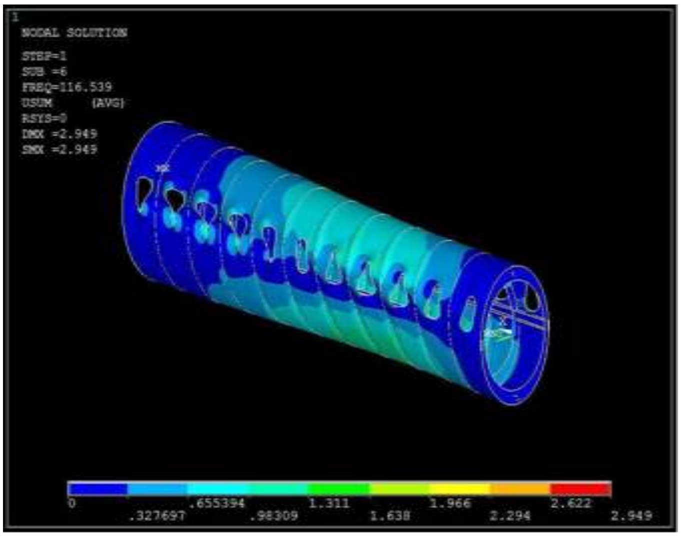

Fig. 9.Mode shape-6 Analysis result.

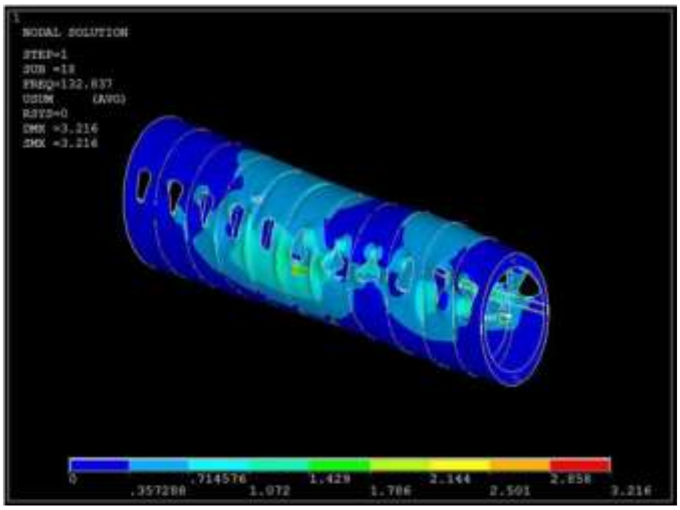

Fig. 10.Mode shape-18 Analysis result.

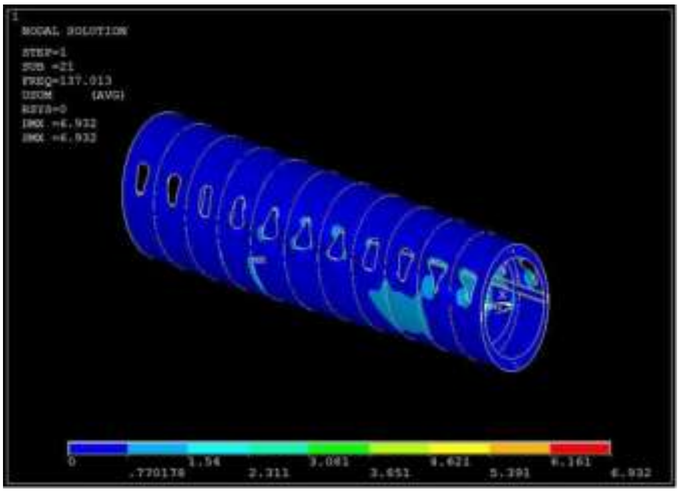

Fig. 11.Mode shape-21 Analysis result.

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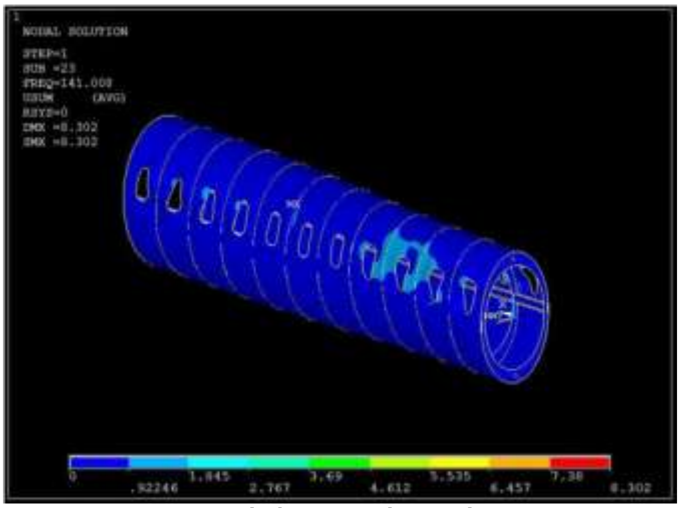

Fig. 12.Mode shape-23 Analysis result.

V. CONCLUTION

The modal analysis and buckling analysis of an aircraft fuselage have been done. The mode shapes, deflection and frequency values have been obtained and discussed. The fuselage has been analyzed using different material properties and all the results obtained are satisfactory. The fuselage structure can be redesigned in much better way using the obtained post-processing results. Structural stability results so obtained through the ANSYS, proves the model to be acceptable.

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